Tidal Structure in Galactic Satellites

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Disclaimer

The work described in this thesis is that of the candidate alone, with the exception of the radial velocities in Chapter 3, which were derived by G. Da Costa. The photographic image in Chapter 2 was constructed by David Malin.

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Abstract

The dynamical histories of three Galactic satellite systems have been investigated. These include the Fornax and Sculptor dwarf spheroidal galaxies, and the globular cluster ω Centauri. Wide-field CCD photometry was obtained for these objects in two colours, V and I, covering a total sky area of 30 square degrees. These data were used to construct a colour-magnitude diagram for each system, which then provided a filter to select probable member stars. This technique reduced contamination from foreground stars, allowing a comprehensive examination of the poorly-known outer regions of these three Galactic satellites.

An initial analysis of the central region of Fornax was made using the deep photometric data provided by Stetson et al. The analysis revealed a shell-like feature located approximately 1.5 core radii southeast from the centre of the dwarf galaxy, with an integrated luminosity of $M_V \sim -4$. The colour-magnitude data for this shell indicate it to be dominated by stars with an age ~ 2 Gyr.

The complete analysis of Fornax utilised two colour data covering a $3.2° \times 3.2°$ area on the sky. The colour-magnitude selection technique revealed a second shell-like feature situated 1.3° northwest from the Fornax centre, approximately $30'$ beyond the nominal tidal radius at this position angle. This feature displays an integrated luminosity of $M_V \sim -7$. The alignment of this second shell is parallel to the original shell, and both are situated on the minor axis. Additionally, a statistical analysis of the extra-tidal region of Fornax revealed two large, faint surface brightness structures located on the minor axis. These structures, combined with the two shells, present strong evidence for shell structure in Fornax. This is the first such structure observed in a dwarf galaxy, and implies that Fornax has experienced a merger event in the recent past.

The photometric survey of Sculptor was complete to the depth of the horizontal branch stars. The red horizontal branch stars were found to be significantly more concentrated than the blue horizontal branch stars. An analysis of the distribution of red giant branch-selected stars revealed no significant extra-tidal structure. To further test this result, spectra at far red wavelengths were obtained for over 700 candidate red giant stars over the 10 deg^2 region using the 2dF instrument on the Anglo-Australian Telescope. Radial velocities and metallicities for these stars were measured using Ca II triplet lines, providing additional constraints to select Sculptor members beyond the nominal tidal radius. The distribution of the 179 probable Sculptor members indicated a lack of extra-tidal stars. These results support, at most, a mild level of interaction between this system and the Galaxy. An upper mass limit for extra-tidal material was measured to be 10% of the Sculptor luminous mass.

The analysis of ω Centauri was similar to that of Sculptor. V and I band

photometry was obtained to search for the tidal tails proposed by a previous study. As noted by others, dust correction was found to remove these structures. G-type spectra were obtained for approximately 4000 candidate cluster members, and radial velocities were used to distinguish members from field stars. A total of 24 probable members of ω Cen were found in the extra-tidal regions. Hence, if ω Cen does possess tidal tails, then they comprise at most 1% of the cluster mass.

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